



Crossing borders, building new ones, or shifting boundaries? Shared narratives and individual paths towards inter/transdisciplinarity in research centres for urban sustainability

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Abstract

Inter/transdisciplinarity (ITD) is a pillar of sustainability studies, often presented as the way to conduct research and practice especially in conflictual and politicised real-world stakeholder constellations. Several studies emphasise the need to consider the communicative processes through which it is put into practice. However, there is still a dearth of research that explores the meanings key actors associate with ITD and how they account for the material, practical and communicative facets of their everyday experience. This work seeks to collect the voice of leaders of inter/transdisciplinary research centres, identify shared repertoires used to interpret their experience in the field, and reflect on how shared narratives could inspire or impede researchers engaged in ITD. A discursive analysis was applied to 23 semi-structured interviews conducted with leaders of research centres on urban sustainability. Results identified diverse *interpretative repertoires* used to define ITD and to interpret the barriers that, in the eyes of these key actors, have to be crossed to become ITD researchers. These elements are combined into three main narratives used by participants to position themselves and the researchers involved in ITD. Despite being functional to self-representation, these shared narratives contribute towards depicting ITD as an individual escape, and interdisciplinary research centres as sanctuaries of a sort, thus paradoxically preserving the status quo. A third narrative advocates structural shifts and is coherent with the need for deeper changes and persistent recognition of ITD in sustainability studies.

Keywords Interdisciplinarity · Transdisciplinarity · Urban sustainability · Barriers · Motivations · Discourse analysis · Interpretative repertoires

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Introduction

Interdisciplinary research (IDR) and transdisciplinary research (TDR) are often deemed essential in sustainability science (Sonetti et al. 2019; Tejedor et al. 2018; von Wehrden et al. 2019). However, in spite of incentives and policy calls directed to foster inter/transdisciplinarity (ITD) (Klein and Newell 1997; Sá 2008; Van Rijnsoever and Hessels 2011), monodisciplinary or, at best, multidisciplinary research efforts (Choi and Pak 2007; Golde and Gallagher 1999) still prevail within universities. Reasons for this include the rigidity of institutional structures and bureaucracy (Boer and Hedges 2006; Buanes and Jentoft 2009; Carayol and Nguyen Thi 2005); a lack of willingness to abandon some self-discipline methods; mutual attitudes and friction (Bruce et al. 2004; Gooch 2005; Morse et al. 2007; Rhoten and Pfirman 2007); difficulties in meeting time requirements (Armstrong and Jackson-Smith 2013; Bruce

et al. 2004; Carayol and Nguyen Thi 2005; Morse et al. 2007); fundraising issues (Fam et al. 2020; Langfeldt and Scordato 2016; Rons 2011; Sá 2008; Schummer 2004); and challenges in managing the steps in ITD research process, like building a collaborative context, co-creating and co-producing transferable knowledge, and integrating it into scientific and societal practice (Lang et al. 2012; OECD 2020).

Cultural and communicative processes are intertwined with these factors. Studies have concentrated on shared modes and visions of ITD (Klein 2014), on local negotiation in discourse and practice (Baptista et al. 2019; Nowacek 2005), and on the individual positioning of researchers (Cuevas-Garcia 2018). However, there is still a dearth of research that gives voice to how leading researchers question and intermingle the material, discursive, and practical facets of their experience. This work seeks to contribute to this debate by examining discursive repertoires and shared narratives (Edwards and Potter 1992; Potter and Wetherell 1987). After focusing on cultural and communicative processes relevant to ITD (societal discourses and definitions, situated negotiations and language, individual positioning and rhetoric), we present a study conducted with a purposive sample of 23 leaders of research centres on urban sustainability. ITD institutes and networks play an enabling role for individuals and institutions, by providing structure as well as symbolic and material support to university change makers (Bolger 2021a, b; Norton et al. 2022). Research centres on urban sustainability are found to be one main institutional response to the quest for ITD research (Hicks and Katz 1996) and have enormously helped the early development of interdisciplinary research (Bozeman and Boardman 2003). They display huge variability in goals, functions, organisational structures, and underlying activities (Sá 2008). At the same time, they share the mission of navigating empirical research, social inquiry, and normative analysis in often conflictual and politicised real-world stakeholder constellations. In our study, we focus on the perspective of key actors who, due to their status, can reinforce or challenge the shared discourse about ITD and create a space for new generations of ITD researchers. By collecting and analysing their narratives, we examined how key actors give meaning to ITD and to the rewards and difficulties they encounter. Our conclusions provide a critical reflection on how shared discourses risk reinforcing the barriers across disciplines rather than contributing to ongoing changes.

Cultural and communicative processes

Societal discourses and definitions of ITD

In the literature, there is no consensus about the meanings of “interdisciplinarity” and “transdisciplinarity,” which are

often used as synonyms and are sometimes even confused with multidisciplinary and cross-disciplinarity. Jensenius (2012) established an interesting classification of “disciplinarity” upon which we build our understanding of ITD in this paper. In Jensenius’ view, under *intradisciplinarity*, teams share a common language, culture, and similar backgrounds (Van Rijnsoever and Hessels 2011). Under *multidisciplinarity* researchers provide their disciplinary knowledge, but are unconcerned with integrating cultures or creating shared knowledge. *Cross-disciplinarity* requires viewing one’s discipline from the perspective of others and is characterised by interaction, cross-fertilisation, and socially inclusive approaches (Szostak 2015). *Interdisciplinarity* aims at integrating knowledge and methods: teams share vocabularies to create new shared knowledge (Van Rijnsoever and Hessels 2011) and provide a holistic or systemic outcome (Bruce et al. 2004). Lastly, *transdisciplinarity* aims at integrating extra scientific knowledge and inputs from different arenas. At this level, knowledge is created and learnt within the teams that collaborate and communicate beyond scientific boundaries (Klein et al. 2001).

Stressing the problem-solving capacity, the National Academy of Sciences (2005) identifies four main shared assumptions behind ITD: (1) *the inherent complexity of nature and society* with enormously complex systems that are influenced by various forces (e.g. climate change, human genome); (2) *the need to explore basic research problems at the interfaces of disciplines*, which stimulates the development of new fields (e.g. biochemistry, computational social sciences); (3) *the need for decision making based on sound science*, and at the same time the acknowledgement that the scientific advancements can create problems that require further scientific and technological solutions (e.g. greenhouse gases, nuclear power); (4) *the stimulus provided by generative technologies* (e.g. the microscope, the Internet) that can transform existing disciplines and generate new ones.

These motivations are at the core of the alternative “modes” for conducting interdisciplinary and transdisciplinary research. Under *Mode 1*, researchers from different disciplines are brought together to overcome an obstacle, to reach a new unity of knowledge, and to move into new and productive areas of research; under *Mode 2*, relevant societal issues require new processes of mutual learning between science and society, and research has a primary problem-oriented approach (Bruce et al. 2004; Gibbons et al. 1994; Scholz and Steiner 2015a).

Taking into account assumptions about goals and communicative aspects, Klein (2014) proposes reducing the different visions to three major discourses: transcendence, problem-solving, and transgression:

- The *transcendence* discourse concerns the dialectic between replacement or integration and mirrors the quest

for unity. In this discourse, ITD is valuable because it goes beyond disciplinary boundaries. Transcendence discourses stress the need to develop a new overarching framework that replaces older science and aims to develop pragmatic or value-based unity of worldviews.

- The *problem-solving* discourse supports ITD as a way to solve wicked problems, generate innovation, and answer questions that cannot be addressed using the linearity of older mono-disciplines (Klein 1990).
- Lastly, the *transgression* discourse construes ITD as a way to break hierarchical views of knowledge, acknowledge multiple voices, and position oneself outside the limits of what was conceived as reliable knowledge.

These three discourses provide an overall framework for understanding scientific and societal tendencies. However, it is worth mentioning here that no single definition is likely to encompass the diverse range of ITD activities, and that some authors consider this definition step as misleading because it distracts from the political dimensions that should be addressed to challenge disciplinary configurations (Jasanoff 2013).

Situated negotiations and language

Societal discourses affect intragroup and intergroup dynamics and are pivotal elements for the success of ITD (Ghosh 2020; Hall and Weaver 2001; Holbrook 2013; Milligan et al. 1999; Morse et al. 2007; Winowiecki et al. 2011). As several authors emphasise, the disciplinary structure of academia does not entail only mastery of the scientific domain, but also a number of habits and the symbolic and cultural resources essential to how communities conduct and give meaning to their activities (Siedlok and Hibbert 2014). “Disciplines shape scientific research by forming the primary institutional and cognitive units in academia [...] Members of a discipline communicate within their community, share basic assumptions and examples about meaningful problems, and set standards for reliable and valid methods, as well as establish what is considered a good solution to a problem.” (Hadorn et al. 2008: 27).

Recent in-depth case studies confirm that differences in methods and languages, issues of power, and divergent ideas about process and outcomes still affect the success of transdisciplinary sustainable projects (Ghosh 2020). Bruce et al. (2004) characterised these dynamics of negotiation, power, and intercultural encounter as “language, terminology and communication issues” and stated that “good communication and listening skills” are among the ideal qualities of interdisciplinary researchers. However, building consensus and learning new methods and languages require extended time, which is barely considered by evaluation procedures (Morse et al. 2007).

The literature suggests addressing this burden from the very beginning of academic training through exposure to other viewpoints (Fam et al. 2020; Klein and Newell 1997; National Academy of Sciences et al. 2005; Sandholtz 2000). Detailed analysis of situated strategies of communication, for example, highlight that informal interactions are fundamental for developing propositions and discursive genres that are used to assimilate and connect diverse views (Nowacek 2005), to facilitate relationships, social and conceptual integration, and to build the mutual understanding and social ties necessary for effective teamwork (Armstrong and Jackson-Smith 2013; Morse et al. 2007).

Individual characteristics, positioning, and rhetoric

Lastly, at the individual level, studies suggest that a particular combination of dispositions, skills and contextual factors can characterise inter/transdisciplinary researchers and determine their trajectories and identity formation (Augsburg 2014). Particularly relevant for individual orientation are curricular structures that include general and liberal education; professional training; social, economic, and technological problem-solving; and social, political, and epistemological critique (Klein and Newell 1997).

Gender perspectives in ITD studies (Rhoten and Pfirman 2007; Van Rijnsoever and Hessels 2011) show that scientists who identify as females are more engaged in interdisciplinary research collaborations (Van Rijnsoever and Hessels 2011). Some authors suggest that women and men may have different learning styles (Halpern 2000; Kimura 1999), career behaviours, and work preferences (Rhoten and Pfirman 2007). However, these are more than just cognitive differences. Research suggests (Max 1982; Rolin 2004) that scientists who identify as females may not be (or wish to be) as committed to the traditional social rules of science and style of interaction. It is, of course, worth emphasising that the modern scientific method and disciplines are based on masculine epistemology, which emphasises the principles of rationality, reductive explanation, and dichotomous partitioning between the social and natural worlds (Fehr 2006; Rhoten and Pfirman 2007). Women are thus also likely to be more marginalised within the culture and structure of traditional science (Rhoten and Pfirman 2007). As a result, and perhaps in spite of work-style preferences, women tend to be more limited in their access to formal and, particularly, informal networks, resources, and opportunities that often foster team collaboration (Corley and Gaughan 2005; Fox 2001). Therefore, women may feel more attracted to participating in unexplored interdisciplinary fields, particularly at the early stages of field development (Rhoten and Pfirman 2007).

Although individual differences can be relevant, individual orientation does not automatically contribute to

research in ITD teams. On the contrary, research suggests that individual and group ITD may be negatively correlated (Locatelli et al. 2021). Auto-ethnographies and rhetoric analysis underscore self-censorship processes and individual positioning: narratives that researchers use to justify their choices to others and the self, and to determine what should or should not be communicated, and how and when (Morse et al. 2007). For example, a rhetoric analysis of 27 interviews in a British University identified recurrent *interpretative repertoires* that dialectically place institutional desires and individual bonus (i.e. intellectual rewards of conducting complex research that adheres to real life) in opposition to the challenges, the precarious path and tension between multiple identities (i.e. the risks of limited disciplinary views and non-rigorous approaches). Within this dialectic, researchers position themselves positively by distinguishing between instrumental interdisciplinarity and authentic and rigorous interdisciplinarity, which characterise the personal intellectual path (Cuevas-Garcia 2018, see also Haider et al. 2018).

The narrative solution to this tension has been often represented as a heroic saga, with “pioneers” of previous generations proving to be able to develop individual careers within the academic context, while at the same time fulfilling transcendence, problem-solving and transgressive goals that are promoted by the overarching societal discourse (Cuevas-Garcia 2015; Klein 2014). Although it might be successful in overcoming structural barriers and achieving individual goals, such a positioning game does not question structural barriers and discipline-based assumptions, and thus paradoxically confirms structural inequalities and power imbalance (Tarabochia 1997).

Aims

Following a discursive research approach (Edwards and Potter 1992; Potter and Wetherell 1987), the present study aims to explore shared definitions of ITD and narratives about individual and group practices. The study examines how ITD is defined, and how research leaders construct individual and group positioning while narrating their experience. Researchers in a leadership position actually play an important role in ITD. They do not only perform structural and processual tasks of boundary spanning and brokering, and managing conflicts within institutions; they also perform a cognitive and cultural task, a visioning process which is referred to as intellectual stimulation by transformational leadership theories and which manifests itself by conceptualising and inspiring the frame shifts described above (Gray 2008).

Based on the reviewed literature, we expected to find some of the discourses observed at the societal level,

especially those aimed at defining motivation and values of ITD, such as *Modes 1 and 2* (Bruce et al. 2004; Gibbons et al. 1994; Scholz and Steiner 2015a) and transcendence, problem-solving, and transgression discourses (Klein 2014).

Furthermore, it is plausible that respondents will use these discourses to rhetorically position themselves in or out of the academic field (e.g. Morse et al. 2007; Cuevas-Garcia 2018).

Lastly, we explored whether certain characteristics of the respondents, primarily gender (e.g. Rhoten and Pfirman 2007), may be predominantly related to choosing certain rhetoric patterns to justify individual choices.

Method

The research is part of a broader project, namely “TrUST—Transdisciplinarity for Urban Sustainability Transition”,¹ which included analysis of websites, interviews, workshops, and an UnConference during 2019, 2020, and 2021, with the aim of better understanding how to achieve better inter-transdisciplinary research and education in current higher education institutions. In the present study, we focus on a purposive sample of respondents from 23 research centres that were part of a larger list included in the research project and identified on the basis of international scientific reputation.

Twenty-three centres decided to participate in this study. All are devoted to research and education. Out of the 23 centres being analysed, 21 specifically declare their mission on their websites. Among the most mentioned motivations, we find advanced fundamental understanding, knowledge sharing, education, public policies, and the addressing of problems (Fig. 1).

From the centres’ websites, it may also be noted that most of the centres are relatively young (although for some, no clear foundation date could be identified). Only 5 out of the 23 centres have a clear private status. The vast majority of the centres are located or operate in Europe, except for one in Hong Kong, and another in Melbourne, Australia (Fig. 2).

The director/coordinator of each centre was contacted by one of the authors and invited to take part in an interview and other activities of the research plan. When the director/coordinator was not available, he/she was asked to indicate one of the prominent researchers in the centre. Respondents (Table 1) who agreed to participate in the study are mostly men (7 F; 16 M) aged between 30 and 60 (coded as m = middle aged; and s = senior > 55). The majority of respondents ($N=16$) hold positions of responsibility as institute head, director of the centre, or coordinator of major projects; the

¹ <https://www.trustcollaboration.com/>.

Fig. 1 Mission of the research centres involved in the study, as declared on their websites

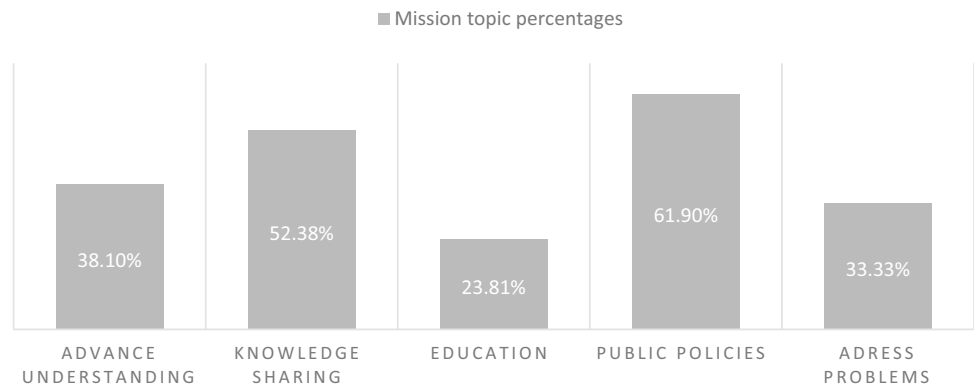


Fig. 2 Geographical location of the research centres involved in the study

remaining respondents ($N=7$) are prominent figures at their centre as lead researchers or coordinators of team units.

In-depth semi-structured interviews were performed online, using triggering questions that touched upon themes derived from the literature:

1. What definition of inter/transdisciplinarity might you provide?
2. In your experience, what are the factors that encourage or hinder inter/transdisciplinary research?
3. How do you pursue ITD research at your centre? How are results evaluated?

The interview was used to solicit identity constructions and argumentations that articulated participants' views and

public discourses (Wetherell and Potter 1992). The method is rooted in one of the psychological traditions in discursive analysis that aims "to make visible the ways in which discourse is central to action, the ways it is used to constitute events, settings and identities, and the various discursive resources that are drawn on to build plausible descriptions." (Potter 2004: 609; see also Antaki and Widdicombe 1998; Bucholtz and Hall 2005). Unlike other analyses of textual data (e.g. content analysis, conversational analysis) "essentially discourse analysis involves developing *hypotheses* about the purposes and consequences of language" (Wetherell and Potter 1988: 170). Following these principles, the interviews were read iteratively by the authors looking at explicit themes, rhetoric, and discursive *interpretative repertoires*, that is, relatively consistent language units that are used by the speakers as building blocks

Table 1 Characteristics of interviewees and research centres

Interviewee				Research centre		
<i>n</i>	Gender	Age range	Role	Year founded	Core SDGs	Typology
1	M	s	Head of unit	2010	6, 7, 13	Public
2	M	s	Head of institute	2011	1–17	Private
3	F	s	Deputy director	2011	–	Public
4	F	s	Coordinator, vice-chair	2015	1–17	Public
5	M	m	Director and professor	1980	3, 4, 6, 9, 11, 12, 13, 17	Public
6	M	s	Project coordinator	1971 and 2017	1–17	Public
7	F	m	Director, project manager	1973	–	Private
8	F	m	Executive director	2017	7, 8, 9, 11, 12	Public
9	F	m	Director, project manager	2004	3, 4, 5, 7, 11, 12, 13	Private
10	M	m	Coordinator, lead researcher	2017	3, 5, 7, 9, 10, 11, 12, 13, 14, 15, 17	Public
11	M	s	Head of institute	Before 2010	1–17	Public
12	M	s	Expert and practitioner	1989	1–17	Public
13	F	s	Lead researcher	–	–	Public
14	M	m	Lead researcher	2015	–	Public
15	M	m	Expert and practitioner	2010	–	Private
16	M	m	CEO	2012	7, 11	Private
17	M	m	Head, professor	–	17, 4	Public
18	M	m	Lead researcher	1883	11, 14, 15	Public
19	M	s	Director, professor	2012	1, 2, 3, 13	Public
20	M	m	Professor	2012	11	Public
21	M	s	Expert and professor	–	6, 7, 13	Public
22	F	s	Co-coordinator	1962	–	Public
23	M	s	Co-director, professor	–	3, 5, 7	Public

for constructing versions of the phenomena and show some regularity of discourses beyond individual variation (Edwards and Potter 1992; Potter and Wetherell 1987; Wetherell and Potter 1988). Specific attention was given to lexical choices, the use of metaphors, images, or narratives. Lastly, shared themes and recurrent *repertoires* enacted by respondents were systematised to reflect upon shared narratives and the functions of these conversational moves (Antaki et al. 2003). The emerging model was critically compared with the examined literature.

Results

The following sections present interpretative repertoires that emerged from our analysis. All these repertoires are largely shared by all our respondents, with no difference due to the role, gender, age, or typology of centre they belong to.

Defining the field: crossing borders from disciplinary to transdisciplinarity

Repertoire: ITD as transgression of the monodisciplinary standard

This first repertoire describes disciplinarity as the normative way of doing research. It often coheres with the representation of academic institutions and with their education and research evaluation standards, including publication procedures and academic career.

“For instance, in most of the work we do, we are missioned according to disciplinary standards like research articles and publications based on disciplinary taking. While when you do interdisciplinary

research, it's more difficult to find channels." (*Interview n.3, line 20*)

Disciplinary standards also indicate how and where to invest, and interviewees exemplify how powerfully the "straight-line" paths attract researchers.

"I would say that for most academics, they're still pretty happy to be pretty disciplinary. (...) most people are where most of the money is. Most of the money is in sort of straight-line stuff." (*Interview n.10, line 37*)

"If they [young students] want to have any hope of an academic career, they have to write and publish on disciplinary newspaper and paper" (*Interview n.8, line 22*)

Consequently, doing ITD is a subversion of the standard way of doing research. Not following such disciplinary standards means straying from the "straight-line" and being "penalised" (8–22).

"(...) I like the use of the word 'transgressing' to describe attempting to operate in this kind of way because it's still not the norm. And it is still seen as transgressive by many people within individual disciplines if you try to step beyond them." (*Interview n.12, line 4*)

Repertoire: ITD as negotiating identities

This repertoire illustrates the symbolic costs of transgression. Disciplinary is described by interviewees through a set of metaphors as part of their identity: the mother tongue, the culture of belonging, the place where they were educated.

"(...) So to me disciplinary, that's fine complementation, shared background, common language. This is how we do things. This is how we think about things." (*Interview n.10, line 10*)

By engaging with ITD, participants thus have to deal with this "disciplinary" part, either as something they actually disclaim or as something of value that researchers have to "lose":

"(...) When we meet other disciplines, we are going to lose some of ours. (...) Once you get to talk with other disciplines, you must let go a lot that you've learnt and that is so important for you." (*Interview n.4, line 32-36*)

Losing something seems to be a prerequisite to cross borders and to interact with unknown "others" placed in different fields.

Repertoire: ITD as interactions that shift boundaries

Through this repertoire, the focus of attention is placed on the system, which is characterised by boundaries with different degrees of permeability.

Rigid boundaries characterise multidisciplinary, which is described as a juxtaposition of perspectives, people, and competencies. To this regard, one participant uses the salad bowl metaphor:

"(...) Multidisciplinary is like having a salad with these different ingredients, but then you can sort of acknowledge which are the different ingredients." (*Interview n.9, line 9-10*)

Interdisciplinarity, instead, like interculturality, requires creating a shared view, a common environment. This transcendence towards unity is what distinguishes interdisciplinarity:

"...people share their expertise and try to build a common platform, a common vocabulary and a common framework to work together almost regardless of what disciplines they come from." (*Interview n.12, line 6*)

Lastly, transdisciplinarity for participants means going beyond the boundaries of the discipline to create something unexpected and new. The kitchen metaphor is used in this regard:

"(...) Transdisciplinary is something different. Here you have something like, you don't have a stew, maybe here you have a kitchen, is something different (..) and then you get things that you never thought that would happen" (*Interview n.9, line 10*)

This transgressive potential distinguishes transdisciplinarity:

"(...) calling for the transgression of duality, subject-object, subjectivity-objectivity, concreteness-consciousness, nature-divine, simplicity-complexity, and of course, the reductionism and holism are all examples of things that need to be reconciled in this understanding of transdisciplinarity." (*Interview n.22, line 32*)

Repertoire: ITD as a vision and moral obligation

Most of the interviewees visualise a continuum leading from mono-, multi-, inter- to transdisciplinarity, the latter being an aspirational value.

"(...) The idea is to move from interdisciplinary to transdisciplinary with a progressive visionary approach for the fostering of cooperation between different ideas." (*Interview n.2, line 39*)

Along with this shared vision, it is also worth mentioning that some respondents (1, 3, 6, 7) highlight a certain degree of fuzziness around multi, inter and transdisciplinarity, and the fact that they are often abused terms: as an interviewee (15) stated, these objects are a “fashionable nonsense,” which simply creates new fields rather than overcoming old boundaries.

In many answers, ITD is presented as almost a moral obligation (“you have to,” “we have to”):

“If you want to be successful in trying to create a more sustainable world, you have to be able to understand how precious things are to people... we have to be able to see how things fit together.” (*Interview n.1, line 30*)

Barriers and drivers

Repertoire: obstacles as a source of self-legitimation

Our respondents refer to almost all barriers to ITD identified in the literature. At the same time, they rhetorically reverse these obstacles into drivers and use them in discourse as a source of self-legitimation.

Closer *institutions* become sources of recognition (e.g. explicit mission and role):

“The way that you described transdisciplinary is problem-solving implementation related to the science in the society. That’s, I think our office would probably feel like that’s what our role is because we are... because we work with everyone” (*Interview n.1, line 17*)

“It was imposed by request, for example, to restructure the Institute to some years ago into a research group. This came from our funding body, the Research Council and Foundation.” (*Interview n.22, line 41*)

Policies and funding schemes from international, EU, regional or governmental institutions are also often cited as structural factors that strongly impact ITD:

“If the policy protocol is not completely suitable or fitting well for the new ideas that are popping up from the discussion, then you have to change the policy. That’s why policies sometimes can be a barrier, we have to understand clearly that we need to change and to update the policy.” (*Interview n. 6, line 27*)

Evaluation and bureaucracy are described by participants as a negative and often illegitimate structural constraint. Consequently, evaluation is described as an imposition that leaves no room for dialogue (“no choice over,” *Interview n.12, line 20*), and conflicts are cited several times in the interviews.

“The conflict between more quantitative or more qualitative evaluator is very important; people are struggling even though the normal idea would be ‘I can use a different perspective to have a more comprehensive understanding of the topic that we are evaluating.’” (*Interview n.7, line 25*)

Criticisms of the evaluation system have to do with not considering alternative approaches to evaluate ITD, such as outcomes and impact.

“I think that research funding in general and transdisciplinary work, in particular, need to be evaluated in terms of its outcomes and impacts.” (*Interview n.12, line 33*)

Time in particular is presented in the interviews: ITD requires time and is built among long-term relationships, and outputs may be assessed after a long time.

“... you don’t know the timing when you will have an impact on the city or a region. You can have a single effect, but then the results come 5, 6, 7 years later, and nobody remembers.” (*Interview n.11, line 39*)

Some respondents thus introduce time as a generational and hierarchical barrier: ITD is exclusive and can be promoted by a “few adults” (who have already progressed in their career), while early researchers lack resources and time to do it. This rhetoric is used to depict ITD as a subversive and almost clandestine way of working (an “alternative way” instead of the “straight-line”).

Shared narratives

The repertoires described in the previous paragraphs are organised into a few shared narratives that mix transcendence, problem-solving and transgression discourses. The first two narratives describe individual paths; the trajectory goes beyond the heroic saga described in the literature and provides visions that include ambivalences and contradictions. A few senior interviewees add a third narrative, which advocates for systemic change.

The individual escape narrative

The first narrative proposes ITD as an individual escape. This narrative focuses on internal characteristics that act as drivers to leave that disciplinary context, which is a box, a silo, a shape that hinders researchers’ ways of conceiving and doing science.

Personality, interests, curiosity, motivation, flexibility, and passion are presented as factors strongly needed to do ITD:

“If it’s linked to some personality types, more open, more flexible, this will help the interpersonal... If you have flexible, open people, it’s easier to put in place this cohesion of the team.” (*Interview n.4, line 48*)

“You need to be open-minded and need to take the time because it is a long process.” (*Interview n.8, line 9*)

Participants often refer to relational qualities, which were not prominent in the examined literature. Empathy, honesty, humility, and humour are presented as factors that facilitate interaction with others:

“It’s something to do with how difficult it is to empathise with other people.” (*Interview n. 12, line 39*)

“Also, somehow admitting that your knowledge is not the whole universe, so maybe some honesty in where your discipline, background and what you need from others. (...) But it also has to do with sort of intellectual honesty, I don’t know how to call it.” (*Interview n.7, line 21*)

Having these characteristics, and because of feeling neither recognised nor rewarded, some researchers “choose” to cross the disciplinary boundaries. As we already noted, such a choice is made not without bearing high costs. It means giving up a safety net, taking risks, and being uncomfortable. This results in a narrative characterised by multiple tensions and inconsistencies; for example, participants claim they need to “get away” from academia, while at the same time wishing to change it by “reintroducing” quality into it.

Flexibility, openness, and tolerance encourage researchers to negotiate with other social actors and, in fact, the ITD strategies and approaches mentioned by participants refer to collaborative processes and conflict management within groups and communities.

“Because that’s me. That’s how I think, that’s how I work. It changes all of us and changes all of us for the better. So we work in this way because that makes sense to us. It’s fun, and it produces, and it’s hard.” (*Interview n.10, line 33*)

However, while transgression and contestation were ideally presented as welcome parts of the co-production of knowledge when looking at ITD practice power relations, authoritarianism, fear and insecurity are cited:

“One thing that I’ve also seen a lot is when you have a transdisciplinary setting, that’s a lot on the power relations between the different players.” (*Interview n.3, line 47*)

Exclusive inclusivity: the sanctuary narrative

The outcome of the “escape” narrative is the constitution of relatively safe spaces, autonomous groups in which members know each other, interact, promote their methodology and create new norms. In this common context, diversity is presented as richness.

In this “sanctuary” narrative, the contribution of every discipline/person/identity is unique, and it is considered a value. ITD is introduced as the production of a shared vision or a shared product that comes from a deep interaction between the group members.

“When you face a problem that is fundamentally complex, it doesn’t have an easy solution and it needs some kind of community or network to be adopted” (*Interview n.17, line 41*)

Interdisciplinary research groups become communities with shared goals and methods, vocabularies, and tools to communicate and manage interactions.

“You come with your professional identity, you come with your disciplinary book vocabulary, or your disciplinary methods and approaches (...). So, we start to make a dictionary of what the project means for each of them. Because at the beginning they were like ‘what are you doing?’” (*Interview n.9, line 29*)

However, borders are again central to this narrative. Groups are “exclusive,” only few researchers can enter, and those who are not engaging in the same effort are ideally left out. Respondents refer to struggling paths, and evoke conflicts within themselves and with institutions. The narratives about researchers’ struggles and (self-evaluated) success ends up with the description of the role held by interviewees as a conquest. The working position can thus be interpreted as a tangible manifestation of the ideal positions that have been conquered and strenuously defended (i.e. a reification).

By staying “outside” the disciplinary box and crossing the borders between academia and society, the new groups are much more in touch with different stakeholders: they look for recognition in scientific contexts and funds from external bodies and governments, while at the same time responding to scientific communities and societal demands. This narrative therefore encompasses a dynamic process in which different forces push towards opposite sides and engage researchers in producing innovative and creative ways of doing research.

ITD researchers, driven by a problem-oriented focus, bypass the academic environment, going to practice and intervention rather than remaining trapped in theoretical lucubration. In this sense, ITD is presented as a problem-oriented approach that fulfils the fundamental mission of Science and Research to benefit communities, and that

can answer demands from different stakeholders, be they institutional partners, evaluators, or beneficiaries of the project. Consistently with the assumptions behind *Mode 2* of transdisciplinary research, knowledge is created within the team and across boundaries:

“To solve real-world problems, they can’t simply work within their own discipline, but need to work with other people who have other expertise that has to be applied to the problem.” (*Interview n.12, line 11*)

At the same time, driven by the need to explore new basic research problems at the crossroads between traditional disciplines, ITD groups are committed to re-creating a new scientific culture with their vocabulary and scientific tools, and engaging in new practices. This commitment is rhetorically presented as rediscovering the ‘authentic’ vision and mission of science as opposed to distorted academic practices:

“There is a gap between the science agenda which seems to be reasonably convinced of the need and desirability of this kind of research and the practice and culture of academia.” (*Interview n.22, line 105*)
 “I don’t think science is focused on improving the sustainability of the planet and society. I think there is like a gap here.” (*n.4, line 9*)

The shifting borders narrative

A third narrative, which we named ‘shifting borders’, is used by fewer participants (4, 6, 12, 22) to shift our attention towards how to change the disciplinary system rather than waiting for individual escapes or seeking sanctuaries. Respondents introduce an intergenerational perspective and convey that one of the biggest obstacles is transmitting, generating, and stimulating ITD to younger and future generations. While the first generation of ITD researchers built sanctuaries, nobody seems to know who is going to guide them in the future.

“I have talked about interdisciplinarity in my research centre, trying to open my colleagues’ minds or at least to let them know about my experiences, but I have not an operational action in my research centre to change it into more interdisciplinary.” (*Interview n.4, line 30*)

The genre, in this narrative, changes from the personal saga to group advocacy. The goal is not individual mobility or community cohesion, but intergroup conflict to change not only the paradigm but the academic system itself, which—where the younger generations are still being “moulded” in disciplinary ways—is seen as a possible way of shifting normative paths for some participants.

“I think and I strongly encourage that this is a different way we should also adopt in the educational curriculum at the university level.” (*Interview n.6, line 29*)
 “Something needs to change in the way we teach disciplines so that students do not become the future scholars or the future practitioners who go out into the world and preach the one religion that they have learned.” (*Interview n.22, line 98*)

In the latter extract, learning and teaching is not introduced as something external to participants. Instead, it has to do with their responsibility (“we” teach disciplines) for interrupting the disciplinary dynamics intrinsic to the academic and educational system. This kind of interpretation recalls the conception of ITD as a phenomenon or a historically, culturally and geographically situated movement, through which minority groups are opposed to the hegemonic approach/actual system which is no longer suitable for today’s world.

However, alternative and concrete options for replacing disciplinary standards in education are still lacking.

“We are still educating the children or students with previous approaches. In the meantime, we are developing new approaches. So, we should transfer this information as soon as possible to the educational level, because otherwise, we are not able to create the change-makers that are needed.” (*Interview n.6, line 32*)

The above extract introduces a generational factor in the sense that “change-makers” have to be grown (“created”) because they will be needed. In sum, this third narrative is the only one that advocates a systemic shift of borders to “interrupt” a model that is no longer considered suitable. If changing the ways research is being evaluated can be seen as changing standards of evaluation of the “outputs,” then modifying the “input” might be shifting away from disciplinary ways of conceiving curricula and courses of study.

Discussion

Results partially confirm our expectations and extend previous studies concerning the discursive construction of what ITD is and of the principles and motives that drive researchers. Societal discourses on ITD (Bruce et al. 2004; Gibbons et al. 1994; Klein 2014; Scholz and Steiner 2015a) are rearranged and used by our respondents to rhetorically position themselves as transgressors of the academic field (e.g. Cuevas-Garcia 2018; Morse et al. 2007). Moreover, it seems that seniority, more than typology of research centre or gender (e.g. Rhoten and Pfirman 2007), is invoked to introduce a shift in rhetoric from individual path to systemic change.

Participants' ideas of disciplinarity, multi, inter and transdisciplinarity match and hybridise the three overarching discourses identified in the literature: transcendence and unity, problem-solving, and transgression (Klein 2014). Participants refer to all the main structural obstacles reported in the literature (disciplinary standards, policies, funding, bureaucracy, time, etc.) and use them to legitimise their position and role. They take up some dichotomies already found in previous studies, such as in the case of the opposition between the fundamental drivers behind ITD and the bureaucratic and disciplinary evaluation practices, or between authenticity and instrumentality (Cuevas-Garcia 2018). Results also emphasise some themes that are not prominent in the examined literature and would require more in-depth exploration, such as the importance given to relational qualities and the acknowledgement that diversity is both hindrance and richness (Haider et al. 2018; Rizzoli et al. 2019).

Unlike what was found in the examined literature, gender does not appear to be a key theme in our interviews. It is not used in the contents as an individual factor used to discriminate between different attitudes, nor does it seem to be related to any specific rhetoric and repertoire. Although this result seems encouraging, it must be stressed that more in-depth study from a gender perspective is undoubtedly necessary. This perspective was not central to the research that was conducted, and the small number of respondents, unbalanced by gender, does not allow clear conclusions to be drawn in this regard.

In spite of these limits, the present study contributes to the literature by showing how shared repertoires are combined into three different, co-existing, and competing narratives. To interpret them, it is useful to deconstruct the path narrated by each respondent through rigid or permeable, legitimate or illegitimate boundaries.

The narrative of the *individual escape*, which in other contexts has been defined as the hero narrative (Cuevas-Garcia 2015; Klein 2014), relies on positive personal characteristics—empathy, open-mindedness and tenacity among others. This narrative is used to underline the researchers' need to cross these porous borders, to transcend, take risks, and move towards groups deemed better for themselves. However, the emphasis on individual mobility does not call into question the disciplinary principles from which our participants rhetorically distance themselves as individuals. Rather, the pain and the symbolic difficulties in abandoning the shared background and language confirm their relevance for individual identity.

The second narrative, *the sanctuary narrative*, again sanctions the closing of intergroup boundaries. This time, boundaries are closed from the inside of ITD groups to build a new positive identity in a community guided by egalitarian, intercultural values. This narrative is rooted in one of the

key characteristics of ITD: its collaborative nature (Aboelela et al. 2007; Cairns et al. 2020; Locatelli et al. 2021). Legitimacy is in this case sought by blending *Mode 1* and *Mode 2* motivations of ITDR (Bruce et al. 2004; Gibbons et al. 1994; Scholz and Steiner 2015a). As in *Mode 1*, ITD legitimacy is sought in the rediscovery of a common framework rooted in the authentic values of science. As in *Mode 2*, legitimacy is sought by interacting with society and through the problem-solving capacity (Klein 1990). As important and disruptive as these narratives are, it should be noted that both present the self and the ingroup in a positive light, while not addressing structural barriers.

By re-presenting these barriers as a source of self-legitimation, and narrating ITD as an individual escape strategy or as an exclusive sanctuary for the few who deserve it, our participants position themselves and ITD in opposition to bad practices. However, while acknowledging the efforts ITD does require, these narratives have a limited impact on the academic system for two reasons. First, they ignore the intergenerational transformations that have taken place since the time of the pioneers, and the diverse mindsets and needs of early-stage researchers who are being undisciplined (Haider et al. 2018; Robinson 2008). Second, they do not challenge the legitimacy and rigidity of the borders, unlike the third identified narrative, i.e. the *shifting border narrative* that could eventually favour a real structural transformation.

In fact, only the third narrative, less present than the other ones, explicitly questions the legitimacy of the academic-disciplinary system, not only for the self, but for the next generations. The *shifting borders* narrative proposes rewriting, upstream, the boundaries between disciplines. It is not a question here of a new, individual way of thinking, but of a new *forma mentis* to be constructed in a true intergenerational perspective (Haider et al. 2018). Compliance with disciplinary divides may be unwise or—following Sardar's definition of “post-normal times”—even unhelpful in dealing with the multiple “ignorance” of our time—that “unlike ordinary ignorance, which is a void to be filled by research and knowledge, requires radically new ways of thinking” (Sardar 2010: 440).

Finalising our analysis, some of this study's limitations should be kept in mind. Although relatively extensive if compared with other studies focusing on single research groups, its results do not aim to be representative. With regard to the centres, while all focusing on urban sustainability, they show a great deal of internal variability. Further research should understand the role of variability across and within centres, e.g. by exploring the peculiarities of interdisciplinary and transdisciplinary programmes within centres, and by exploring centres that have other themes at their core (e.g. large STEM projects). With regard to the interviewees, they have a similar socio-economic context and a European

vision; in addition, we investigated the vision of directors and coordinators. Further studies, e.g. ethnographic and conversational ones, are needed to investigate narratives at different hierarchical levels, and how they are negotiated in daily practices (e.g. with students, funders).

Conclusion

In this study, we interviewed leaders in the field of ITD research on urban sustainability to trace the definitions and discourses through which they construct their field. Indeed, their visions are worth keeping in mind if we want to go beyond the normative nobility of ITD promoted at the policy level (Ghosh 2020; Klein and Falk-Krzesinski 2017) and investigate the relationship between structural barriers and communicative and relational processes beyond ideal types (Baptista et al. 2019; Scholz and Steiner 2015a, b).

Research leaders and managers, as our results show, are well aware of all major impediments for ITD, and could play a crucial role in overcoming these boundaries. In the eyes of the key actors, ITDR is often less rewarding in terms of publications, recognition and career advancement. Our results are also consistent with what many authors argue: existing evaluation structures act as a barrier for ITD (Boer and Hedges 2006; Wagner et al. 2011); criteria for project evaluation are often biased and may disfavour interdisciplinary and other kinds of non-conventional research (Klein 2008; Langfeldt and Scordato 2016; Metzger and Zare 1999; Rhoten and Pfirman 2007); IDR collaborations are unrelated to academic rank (Van Rijnsoever and Hessels 2011); and there is a risk of free riders or mercenary attitudes that heavily affect the success of ITD sustainability research (Ghosh 2020).

Moreover, we identified two main actions that are already emerging, albeit with difficulty, and which could support and reinforce the transformative capacity of the third narrative. The first is legitimation. In the narratives we collected, the interviewees referred to ideal (i.e. science), proximal (i.e. one's own institutions) and internal (i.e. personal characteristics) sources of legitimacy. Although shared criteria for assessment of ITD are still needed (Klein and Newell 1997; Krott 2002), and no objective methods have been established for evaluating academicians' productivity or the levels of interdisciplinary integration (Anzai et al. 2012), several interesting proposals for structural change have been developed during the last decades (a "measure of interdisciplinarity," Carayol and Nguyen Thi 2005; indicators for project processes and performance, Knight and Pettigrew 2007; an "integration index", Porter and Rafols 2009; performance evaluations and academic staff appointments, Van Rijnsoever and Hessels 2011; seven principles that provide a

valuable starting point for standardised procedures for ITD assessment, Klein 2008). Tangible examples of the uptake of these ideas may be pointed out: the European Science Foundation, for example, now considers "Collaborative Research Projects" as one of the seven specific categories of funding instruments. The National Academy of Science also provides "special evaluation measures of IDR programs" as one of their institutional recommendations. However, even these schemes will prove insufficient unless combined with a more radical rethinking of power relations and the underlying order of values, which translates into criteria of efficiency and time that are intrinsically incompatible with a different way of doing research (Felt et al. 2016).

A second area in which ongoing transformation could nurture the *shifting boundaries* narrative is to be found outside, and sometimes explicitly against (Sonetti et al. 2020a, b) the disciplinary structure of academia. This was an artefact of the nineteenth and twentieth centuries' social and political organisation (Wagner et al. 2011), and nowadays many stress that this organisation hampers potentially valuable and innovative interactions (Rons 2011). There is a historical claim that the disciplinary mode of research and teaching leads to excessive fragmentation of knowledge (Klein 1990; National Academy of Sciences et al. 2005) and that subdivision of disciplines leads to "silos" that impede needed communication across disciplinary and organisational boundaries (Arrobbio and Sonetti 2021; Sá 2008; Sonetti et al. 2020a, b).

Indeed, for the intercultural approach, to promote innovation, development, well-being and sustainability, we need to hybridise, cross-pollinate, and contest rigid boundaries, both from within and from outside. This also means a process of (de)construction of sociocultural issues that have characterised individuals, groups, and institutions (Norton 2020).

Currently, successful research and educational pathways expose interdisciplinary training from the earliest years of study, and challenge at the core the asserted disciplinarity of academia—which we found in our interviews as well.

To conclude, many experiences suggest that borders across disciplines are becoming less and less rigid and legitimate. Going beyond the escape and the sanctuary narratives requires moving from the individual and intragroup focus to the structural one. A *shifting border* narrative, whether it will be further developed and supported concerning the structural changes already in place, has the potential to tackle legitimacy and rigidity of boundaries from the foundation. The aim for those who frankly recognise the relevance of diversity in research, especially when holding leadership positions (Gray 2008), should also be to raise a new generation of inter-transdisciplinary researchers, without requiring them to be new heroes or to find salvation in sanctuaries, but merely giving them space and legitimacy

to be good scholars and human beings taking care of themselves (Sellberg et al. 2021), their scientific processes, and these processes' societal impacts.

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Declarations

Ethical approval All procedures in studies involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments, or comparable ethical standards.

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References

- Aboelela SW, Larson E, Bakken S, Carrasquillo O, Formicola A, Glied SA, Haas J, Gebbie KM (2007) Defining interdisciplinary research: conclusions from a critical review of the literature. *Health Serv Res* 42:329–346
- Antaki C, Widdicombe S (1998) *Identities in talk*. Sage, London
- Antaki C, Billig M, Potter J (2003) Discourse analysis means doing analysis: a critique of six analytic shortcomings. *Athenea Digit Revista De Pensamiento e Investigación Social* 1(3):14. <https://doi.org/10.5565/rev/athenead/v1n3.64>
- Anzai T, Kusama R, Kodama H, Sengoku S (2012) Holistic observation and monitoring of the impact of interdisciplinary academic research projects: an empirical assessment in Japan. *Technovation* 32(6):345–357. <https://doi.org/10.1016/j.technovation.2011.12.003>
- Armstrong A, Jackson-Smith D (2013) Forms and levels of integration: evaluation of an Interdisciplinary Team-Building Project. *J Res Pract* 9(1):M1
- Arrobbio O, Sonetti G (2021) Cinderella lost? Barriers to the integration of energy Social Sciences and Humanities outside academia. *Energy Res Soc Sci* 73:101929
- Augsburg T (2014) Becoming transdisciplinary: the emergence of the transdisciplinary individual. *World Futures* 70(3–4):233–247. <https://doi.org/10.1080/02604027.2014.934639>
- Baptista BV, Maryl M, Wcislik P, Fletcher I, Buchner A, Wallace D, Pohl C (2019) SHAPE-ID: Shaping Interdisciplinary Practices in Europe Deliverable 2.1: preliminary report of literature review on understandings of interdisciplinary and transdisciplinary research project information
- Boer YM, Hedges M (2006) *Building bridges: researchers on their experiences with interdisciplinary research in the Netherlands*. RMNO, The Hague
- Bolger P (2021a) Delivering on the promise: how are sustainability research institutes enabling interdisciplinary research? *Int J Sustain High Educ* 22(8):167–189. <https://doi.org/10.1108/IJSHE-10-2020-0415>
- Bolger P (2021b) A study of faculty perceptions and engagement with interdisciplinary research in university sustainability institutes. *J Environ Stud Sci* 11(1):115–129
- Bozeman B, Boardman C (2003) *Managing the new multipurpose, multidiscipline university research centers*. Institutional Innovation in the Academic Community, IBM Centre for the Business of Government, November, 55
- Bruce A, Lyall C, Tait J, Williams R (2004) Interdisciplinary integration in Europe: the case of the fifth framework programme. *Futures* 36(4):457–470. <https://doi.org/10.1016/j.futures.2003.10.003>
- Buanes A, Jentoft S (2009) Building bridges: institutional perspectives on interdisciplinarity. *Futures* 41(7):446–454. <https://doi.org/10.1016/j.futures.2009.01.010>
- Bucholtz M, Hall K (2005) Identity and interaction: a sociocultural linguistic approach. *Discourse Stud* 7(4–5):585–614
- Cairns R, Hielscher S, Light A (2020) Collaboration, creativity, conflict and chaos: doing interdisciplinary sustainability research. *Sustain Sci* 15(6):1711–1721. <https://doi.org/10.1007/s11625-020-00784-z>
- Carayol N, Nguyen Thi TU (2005) Why do academic scientists engage in interdisciplinary research? *Res Eval* 14(1):70–79. <https://doi.org/10.3152/147154405781776355>
- Choi BCK, Pak AWP (2007) Multidisciplinarity, interdisciplinarity, and transdisciplinarity in health research, services, education and policy: 2. Promotors, barriers, and strategies of enhancement. *Clin Investig Med* 30(6):E224–E232
- Corley E, Gaughan M (2005) Scientists' participation in University Research Centers: what are the gender differences? *J Technol Transf* 30(4):371–381
- Cuevas-Garcia CA (2015) 'I Have Never Cared for Particular Disciplines'—negotiating an interdisciplinary self in biographical narrative. *Contemp Soc Sci* 10(1):86–98. <https://doi.org/10.1080/21582041.2014.974664>
- Cuevas-Garcia CA (2018) Understanding interdisciplinarity in its argumentative context: thought and rhetoric in the perception of academic practices. *Interdiscipl Sci Rev* 43(1):54–73. <https://doi.org/10.1080/03080188.2016.1264133>
- Edwards D, Potter J (1992) *Discursive psychology*. Sage, London
- Fam D, Clarke E, Freeth R, Derwort P, Klaniecki K, Kater-Wettstädt L, Juarez-Bourke S, Hilser S, Peukert D, Meyer E, Horcea-Milcu A (2020) Interdisciplinary and transdisciplinary research and practice: balancing expectations of the 'Old' academy with the future model of universities as 'Problem Solvers.' *High Educ Q* 74(1):19–34. <https://doi.org/10.1111/hequ.12225>
- Fehr C (2006) Feminism and science: mechanism without reductionism. *NWSA J* 136–156. <https://doi.org/10.2979/nws.2004.16.1.136>. In: *Removing barriers: women in academic science, technology, engineering, and mathematics*
- Felt U, Igelsböck J, Schikowitz A, Völker T (2016) Transdisciplinary sustainability research in practice: between imaginaries of collective experimentation and entrenched academic value orders. *Sci Technol Hum Values* 41(4):732–761

- Fox MF (2001) Women, science, and academia: graduate education and careers. *Gend Soc* 15(5):654–666
- Ghosh A (2020) Deconstructing a 2-year long transdisciplinary sustainability project in Northern universities: is rhetorical nobility obscuring procedural and political discords? *Sustain Sci* 15(4):1111–1127. <https://doi.org/10.1007/s11625-020-00816-8>
- Gibbons M, Limoges C, Nowotny H, Schwartzmann S, Scott P, Trow M (1994) *The new production of knowledge*. Sage, London
- Golde CM, Gallagher HA (1999) The challenges of conducting interdisciplinary research in traditional doctoral programs. *Ecosystems* 2(4):281–285. <https://doi.org/10.1007/s100219900076>
- Gooch JC (2005) The dynamics and challenges of interdisciplinary collaboration: a case study of ‘Cortical Depth of Bench’ in group proposal writing. *IEEE Trans Prof Commun*. <https://doi.org/10.1109/TPC.2005.849646>
- Gray B (2008) Enhancing transdisciplinary research through collaborative leadership. *Am J Prev Med* 35(2):S124–S132. <https://doi.org/10.1016/j.amepre.2008.03.037>
- Hadorn GH, Hoffmann-Riem H, Biber-Klemm S, Grossenbacher-Mansuy W, Joye D, Pohl C, Wiesmann U, Zemp E (eds) (2008) *Handbook of transdisciplinary research*, vol 10. Springer, Dordrecht
- Haider LJ, Hentati-Sundberg J, Giusti M, Goodness J, Hamann M, Masterson VA, Meacham M, Merrie A, Ospina D, Schill C, Sinare H (2018) The undisciplined journey: early-career perspectives in sustainability science. *Sustain Sci* 13(1):191–204. <https://doi.org/10.1007/s11625-017-0445-1>
- Hall P, Weaver L (2001) Interdisciplinary education and teamwork: a long and winding road. *Med Educ* 35(9):867–875. <https://doi.org/10.1046/j.1365-2923.2001.00919.x>
- Halpern DF (2000) Sex differences in cognitive abilities. L. Erlbaum Associates, Mahwah
- Hicks DM, Katz JS (1996) Where is science going? *Sci Technol Hum Values* 21(4):379–406
- Holbrook JB (2013) What is interdisciplinary communication? Reflections on the very idea of disciplinary integration. *Synthese* 190(11):1865–1879. <https://doi.org/10.1007/s11229-012-0179-7>
- Jasanoff S (2013) *Fields and fallows: a political history of STS. Interdisciplinarity: reconfigurations of the social and natural sciences*. Routledge, London, pp 99–118
- Jensenius AR (2012) *Disciplinarity: intra, cross, multi, inter, trans*. Blog Post March 12, 2012. <https://www.arj.no/2012/03/12/disciplinarity-2/>
- Kimura D (1999) *Sex and cognition*. MIT Press, London
- Klein JT (1990) *Interdisciplinarity: history, theory, and practice*. Wayne State University Press, Detroit
- Klein JT (2008) Evaluation of interdisciplinary and transdisciplinary research. A literature review. *Am J Prev Med* 35(2):S116–S123. <https://doi.org/10.1016/j.amepre.2008.05.010>
- Klein JT (2014) Discourses of transdisciplinarity: looking back to the future. *Futures* 65:10–16. <https://doi.org/10.1016/j.futures.2014.08.008>
- Klein JT, Falk-Krzesinski HJ (2017) Interdisciplinary and collaborative work: framing promotion and tenure practices and policies. *Res Policy* 46(6):1055–1061
- Klein JT, Newell WH (1997) Advancing interdisciplinary studies. In: Gaff JG, Rateliff JL (eds) *Handbook of the undergraduate curriculum: a comprehensive guide to purposes, structures, practices, and change*. Jossey-Bass Publishers, San Francisco, pp 393–415
- Klein JT, Grossenbacher-Mansuy W, Haberli R, Bill A, Scholz RW, Welti M (eds) (2001) *Transdisciplinarity: joint problem solving among science, technology, and society: an effective way for managing complexity*. Springer Science and Business Media, Berlin
- Knight L, Pettigrew A (2007) Explaining process and performance in the co-production of knowledge: a comparative analysis of collaborative research projects. In: *Third organization studies summer workshop*, Rethymno, Crete, Greece
- Krott M (2002) Evaluation of transdisciplinary research. In: Hadorn GH (ed) *Unity of knowledge in transdisciplinary research for sustainability*, vol 2. *Encyclopedia of Life Support Systems (EOLSS)* Publishers, Oxford
- Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P, Swilling M, Thomas CJ (2012) *Transdisciplinary research in sustainability science: practice, principles, and challenges*. *Sustain Sci* 7(1):25–43
- Langfeldt L, Scordato L (2016) Efficiency and flexibility in research funding. A comparative study of funding instruments and review criteria. Report 2016: 9. Nordic Institute for Studies in Innovation, Research and Education (NIFU)
- Locatelli B, Vallet A, Tassin J, Gautier D, Chamaret A, Sist P (2021) Collective and individual interdisciplinarity in a sustainability research group: a social network analysis. *Sustain Sci* 16(1):37–52. <https://doi.org/10.1007/s11625-020-00860-4>
- Max C (1982) Career paths for women in physics. *Women and minorities in science: strategies for increasing participation*. Westview, Boulder, pp 99–118
- Metzger N, Zare RN (1999) Interdisciplinary research: from belief to reality. *Am Assoc Adv Sci* 283(5402):642–643. <https://doi.org/10.1126/science.283.5402.642>
- Milligan RA, Gilroy J, Katz KS, Rodan MF, Subramanian KN (1999) Developing a shared language: interdisciplinary communication among diverse health care professionals. *Holist Nurs Pract* 13(2):47–53. <https://doi.org/10.1097/00004650-199901000-00008>
- Morse WC, Nielsen-Pincus M, Force JE, Wulforth JD (2007) Bridges and barriers to developing and conducting interdisciplinary graduate-student team research. *Ecol Soc* 12(2):8. <http://www.ecologyandsociety.org/vol12/iss2/art8/>
- National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (2005) *Facilitating interdisciplinary research*. The National Academies Press, Washington, DC. <https://doi.org/10.17226/11153>
- Norton LS (2020) (De) constructing bridges for development and innovation: intercultural concerns regarding ICT4D. *Am Behav Sci* 64(13):1921–1932
- Norton LS, Sarrica M, Lombardi R, Peruzzi G (2022) Discourses on sustainability in a network of Argentine universities: exploring representations, cultural roots and transformative processes. *Int J Sustain High Educ*. <https://doi.org/10.1108/IJSHE-07-2021-0283>
- Nowacek RS (2005) A discourse-based theory of interdisciplinary connections. *J Gen Educ* 54(3):171–195. <https://doi.org/10.1353/jge.2006.0006>
- OECD (2020) *Addressing societal challenges using transdisciplinary research*. OECD Science, Technology and Industry Policy Papers (June) No. 88, Paris. <https://www.oecd.org/science/addressing-societal-challenges-using-transdisciplinary-research-0ca0ca45-en.htm>
- Porter AL, Rafols I (2009) Is science becoming more interdisciplinary? Measuring and mapping six research fields over time. *Scientometrics* 81(3):719–745. <https://doi.org/10.1007/s11192-008-2197-2>
- Potter J (2004) *Discourse analysis*. In: Hardy M, Bryman A (eds) *Handbook of data analysis*. Sage, London, pp 607–624
- Potter J, Wetherell M (1987) *Discourse and social psychology: beyond attitudes and behaviour*. Sage, London
- Rhoten D, Pfirman S (2007) Women in interdisciplinary science: exploring preferences and consequences. *Res Policy* 36(1):56–75. <https://doi.org/10.1016/j.respol.2006.08.001>
- Rizzoli V, Castro P, Tuzzi A, Contarello A (2019) Probing the history of social psychology, exploring diversity and views of the social:

- publication trends in the European Journal of Social Psychology from 1971 to 2016. *Eur J Soc Psychol* 49(4):671–687
- Robinson J (2008) Being undisciplined: transgressions and intersections in academia and beyond. *Futures* 40(1):70–86
- Rolin K (2004) Why gender is a relevant factor in the social epistemology of scientific inquiry. *Philos Sci* 71(5):880–891
- Rons N (2011) Interdisciplinary research collaborations: evaluation of a funding program. *Collnet J Scientomet Inf Manag* 5(1):17–32. <https://doi.org/10.1080/09737766.2011.10700900>
- Sá CM (2008) ‘Interdisciplinary strategies’ in US Research Universities. *High Educ* 55(5):537–552. <https://doi.org/10.1007/s10734-007-9073-5>
- Sandholtz JH (2000) Interdisciplinary team teaching as a form of professional development. *Teach Educ Quart* 27(3): 39–54. <http://www.jstor.org/stable/23478234>
- Sardar Z (2010) Welcome to postnormal times. *Futures* 42(5):435–444
- Scholz RW, Steiner G (2015a) The real type and ideal type of transdisciplinary processes: part I—theoretical foundations. *Sustain Sci* 10(4):527–544. <https://doi.org/10.1007/s11625-015-0326-4>
- Scholz RW, Steiner G (2015b) Transdisciplinarity at the crossroads. *Sustain Sci* 10(4):521–526
- Schummer J (2004) Multidisciplinarity, interdisciplinarity, and patterns of research collaboration in nanoscience and nanotechnology. *Scientometrics* 59(3):425–465. <https://doi.org/10.1023/B:SCIE.0000018542.71314.38>
- Sellberg MM, Cockburn J, Holden PB, Lam DP (2021) Towards a caring transdisciplinary research practice: navigating science, society and self. *Ecosyst People* 17(1):292–305
- Siedlok F, Hibbert P (2014) The organization of interdisciplinary research: modes, drivers and barriers. *Int J Manag Rev* 16(2):194–210. <https://doi.org/10.1111/ijmr.12016>
- Sonetti G, Brown M, Naboni E (2019) About the triggering of UN sustainable development goals and regenerative sustainability in higher education. *Sustainability (Switzerland)* 11(1):254
- Sonetti G, Arrobbio O, Lombardi P, Lami IM, Monaci S (2020a) ‘Only Social Scientists Laughed’: reflections on social sciences and humanities integration in European energy projects. *Energy Res Soc Sci* 61:101342
- Sonetti G, Barioglio C, Campobenedetto D (2020b) Education for sustainability in practice: a review of current strategies within Italian universities. *Sustainability* 12(13):5246
- Szostak R (2015) Extensional definition of interdisciplinarity. *Issues Interdiscipl Stud* 33:94–116
- Tarabochia S (1997) Language and relationship building: analyzing discursive spaces of interdisciplinary collaboration. *Across Discipl J Lang Learn Acad Writ* 10(2):n2
- Tejedor G, Segalàs J, Rosas-Casals M (2018) Transdisciplinarity in higher education for sustainability: how discourses are approached in engineering education. *J Clean Prod* 175:29–37
- Van Rijnsoever FJ, Hessels LK (2011) Factors associated with disciplinary and interdisciplinary research collaboration. *Res Policy* 40(3):463–472. <https://doi.org/10.1016/j.respol.2010.11.001>
- Von Wehrden H et al (2019) Interdisciplinary and transdisciplinary research: finding the common ground of multi-faceted concepts. *Sustain Sci* 14(3):875–888
- Wagner CS, Roessner JD, Bobb K, Klein JT, Boyack KW, Keyton J, Rafols I, Börner K (2011) Approaches to understanding and measuring interdisciplinary scientific research (IDR): a review of the literature. *J Informet* 5(1):14–26. <https://doi.org/10.1016/J.JOI.2010.06.004>
- Wetherell M, Potter J (1988) Discourse analysis and the identification of interpretative repertoires. In: Antaki C (ed) *Analysing everyday explanation. A casebook of methods*. Sage Publications, London, pp 168–184
- Wetherell M, Potter J (1992) *Mapping the language of racism: discourse and the legitimation of exploitation*. Harvester Wheatsheaf and Columbia University Press, London and New York
- Winowiecki L, Smukler S, Shirley K, Remans R, Peltier G, Lothes E, King E, Comita L, Baptista S, Alkema L (2011) Community essay tools for enhancing interdisciplinary communication. *Sustain Sci Pract Policy* 7(1):74–80. <https://doi.org/10.1080/15487733.2011.11908067>

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